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Cone and Seed Size of South Florida Slash Pine and Their Effects on Seedling Size and Survival

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SOUTH FLORIDA slash pine (*Pinus elliottii* var. *densa* Little and Dorman) once grew in pure even-aged stands on more than 2 million acres of peninsular Florida (*6, 7*). Over one half of this area is now poorly stocked or denuded because of wildfires and past timber cutting. In the past, attempts to restock these cutover lands by planting south Florida slash pine have often failed because of poor first year survival. Inferior nursery stock, improper handling and planting, and rigorous site conditions with alternate periods of high ground water and drought were some of the factors contributing to seedling mortality. To improve the quality of the planting stock (Fig. 1), it is desirable to understand the effects of cone, seed, and seedling size on seedling growth and survival.

Past Work

Past work with cone size in other pines has been concerned mainly with its relation to seed yields and to germination. Studies of red pine have indicated that production of viable seed increases with cone size (*14*). A study of pitch pine showed that the larger cones yielded heavier seed with somewhat better germination than the lighter seed from medium and small cones (*10*). However, in this study the small and medium sized cones of shortleaf pine contained more viable seed than did the large cones (*10*).

Seed weight, or size, has been found to have an effect on the germination, survival, or early size of seedlings of Scots pine, eastern white pine (*8, 9, 12*), and red pine (*3*). Seed size of ponderosa and Jeffrey pines did not affect survival in transplant beds but did affect growth for the first three years (*2*).

Seedling size is usually an important factor in survival and early growth. The larger seedlings usually survive and grow best, although the southern pines are exceptions to this rule (*15*). Jack pine and red pine survive best when the smallest and poorest seedlings are discarded (*11, 13*), but for ponderosa and Jeffrey pine, seedling size may have little effect on survival until the second year after planting (*2*). For shortleaf pine, the seedlings with the smallest stem diameter usually had the poorest survival, while seedling height alone had little effect. The seedlings with low height-diameter ratios generally had the best survival (*1*).

Procedure

Since nothing has yet been reported on any of these relationships for South Florida slash pine,[1] the study reported here was designed to provide such information. The study was made in cooperation with the Florida Board of Forestry, The Atlantic Land and Improvement Company, and the Collier Enterprise. The seed used was taken from a 250-bushel lot collected from a large mature stand in Hendry County, Florida, in October 1952.

Cone grades. — Ten ½-bushel samples were selected at random

[1]This species was recognized as a new variety of pine in 1952 by Little and Dorman (*4, 5*).

FIG. 1.—One-year-old seedling of South Florida slash pine, showing the characteristic carrot-like tap root and short, thick stem.

from the 250-bushel lot, combined into one 5-bushel sample, and then graded into 3-, 4-, 5-, and 6-inch length cone size classes. The cone sizes ranged from 2½ to 6½ inches in length. In the sample used, 19 percent were in the 3-inch class, 56 percent in the 4-inch class, 22 percent in the 5-inch class, and only 3 percent in the 6-inch class. Although the range of cone sizes for the two varieties of slash pine overlap, cones of South Florida slash pine are smaller than those of common slash pine (*5*). In this study the cones averaged 246 cones per bushel, nearly one-fourth more than for common slash pine (*15*).

Seed grades.—A ½-bushel lot of cones from each cone size class was allowed to dry and open at room temperature in separate screen-wire trays. After the cones opened, the seed was extracted and de-winged by hand rubbing. The seed was cleaned with a 14-inch fan. The fanning was vigorous enough to remove all of the wings and nearly all of the empty seeds. Cutting tests with ocular inspection of the seed showed that 95 percent or more of the seed in each cone-length class had normally developed endosperms.

Eight random samples of 200 sound seeds each were taken from each cone class to obtain seed weight by cone length. The air-dried seed from each cone class was then separated into seed-size classes by using U. S. Standard sieve sizes of square mesh:

Seed size *Class*	Size range *Millimeters*
Extra large	4.00+
Large	3.36—4.00
Medium	2.83—3.36
Small	2.38—2.83
Small	2.00—2.38
Small	1.41—2.00

An additional four random samples of 100 seeds each were selected from each cone and seed class and weighed to determine relation of number of seed and weight for all combinations of seed and cone sizes.

The seed from each cone and seed class was then planted in the Keri nursery[2] on April 7, 1953, in a randomized block design with two replications. Prior to sowing, the nursery beds were treated with 1,000 pounds of 6-6-6 fertilizer and 500 pounds of superphosphate per acre. The seed was sown at the rate of 25 seeds per lineal foot. The seedbed density was fairly uniform, with about 12.6 seedlings per lineal foot, except for the small and extra large seed-size classes which averaged only 4.2 and 8.8 seedlings per lineal foot. Seedlings from these two seed-size classes were not outplanted. Normal irrigation and weed control practices were followed until seedlings were lifted in December, eight months later.

Seedling grades. — After being lifted, the seedlings from each cone and seed class were graded into large, medium, and small size classes based on stem height and diameter at root collar. The extra large and small seed classes, because of the small amount of seed, did not produce the minimum number of 300 seedlings required for outplanting. These treatments (classes) were dropped from study after seedling height, diameter, and weight had been measured.

The three seedling grades used were based on the following height (root collar to bud tip) and stem-diameter sizes:

Seedling grade	Seedling height *Inches*	Stem diameter *Inches*
Small	1 - 3	Less than 1/16
Small	1 - 2	1/16 - 1/4
Medium	1 - 2	1/4 - 3/8
Medium	2 - 3	1/16 - 1/4
Medium	3 - 4	Less than 1/16
Large	2 - 3	1/4 - 1/2
Large	3 - 8	1/16 - 1/2

It should be pointed out that the seedling grades used combined both stem diameter and height measurements and in view of Chapman's findings (previously discussed), the combination may have modified the survival by seedling grades.

After being graded, the seedlings were placed in bundles of 25 and weighed (green weight) as a check on seedling grading procedure. The check showed that within a given cone-seed size class the seedlings of different grade were of significantly different green weight.

Outplanting. — The seedlings were outplanted in a randomized split-plot design with four replications. Twenty-four different grades were planted, based on the combinations of four cone grades, two seed grades, and three seedling grades.

Effect of Grades on First-Year Survival and Growth

One year after field planting, seedling survival among seed grades by cone lengths was very significantly different. Large seed from small cones gave best survival. There was a significant interaction between cone length and seed size,

TABLE 1.—SEEDLING SURVIVAL ONE YEAR AFTER PLANTING, BY CONE, SEED, AND SEEDLING GRADES, SOUTH FLORIDA SLASH PINE

Cone length (Inches)	Seed size	Seedling grade: Large	Medium	Small	Average
		Percent			
3	Large	83	87	81	83.7
3	Medium	51	67	48	55.3
4	Large	88	86	75	83.0
4	Medium	51	58	58	55.7
5	Large	78	74	69	73.7
5	Medium	85	76	80	80.3
6	Large	60	71	51	60.7
6	Medium	40	33	41	38.0
Average, large seed		77.3	79.5	69.0	75.3
Average, medium seed		56.8	58.5	56.8	57.3
Average, all seed		67.0	69.0	62.9	66.3

[2]Owned and operated near La Belle, Florida, by the Atlantic Land and Improvement Company.

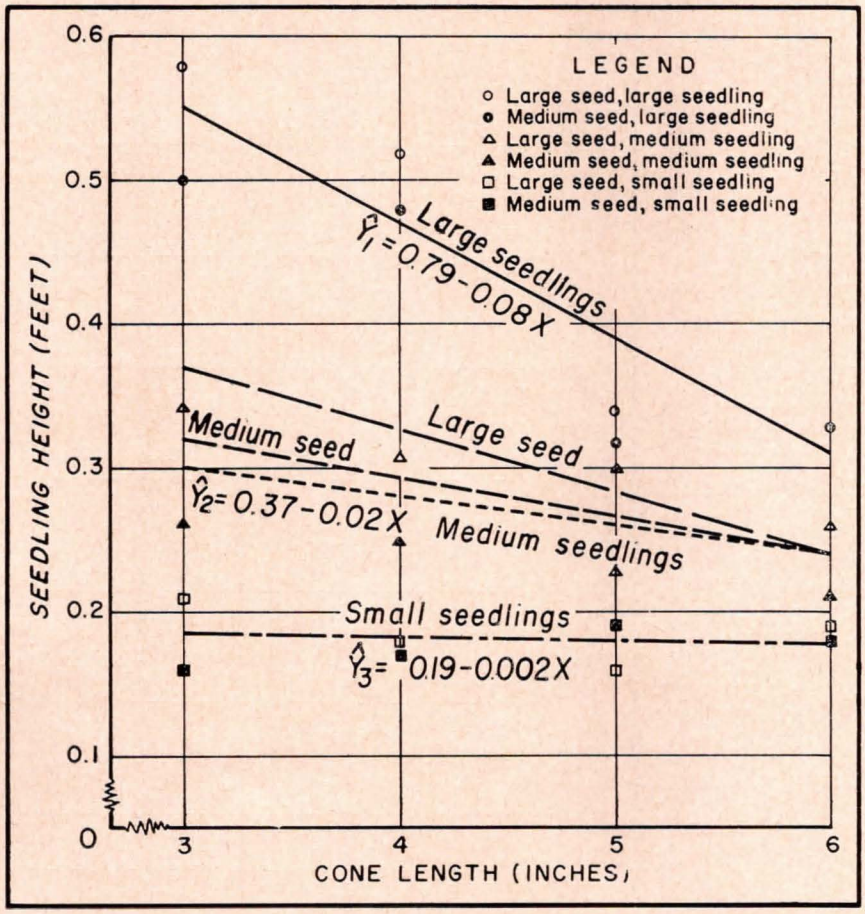

FIG. 2.—Effect of cone, seed, and seedling grades on seedling height one year after planting, South Florida slash pine.

attributable to a reversal in the 5-inch cone length group (Table 1). Survival of large, medium, and small seedlings was 67.0, 69.0, and 62.9 percent, respectively. These differences were not significant at the 5 percent level, but they were significant at about the 10 percent level.

In spite of the fact that differences in seedling growth are characteristically narrow for this species, an analysis of total height 1 year after field planting did reveal several significant trends. As expected, the average seedling heights —0.43, 0.27, and 0.18 feet for the large, medium, and small seedling grades respectively—were significantly different. As in survival, the heights of the seedlings from seed of a given size showed a highly significant inverse relation to cone size. Differences in height attributable to seed size one year after outplanting were not significant at the 5 percent level. The interaction between seedling and cone grades was highly significant, and is illustrated in Figure 2 by the slope of the regression.

Cone, Seed, and Seedling Characteristics

Cone and seed sizes.—A definite relationship was found between cone length and seed-size distribution. This relationship is illustrated by Figure 3, which shows the percent distribution of seed by seed and cone size on a cumulative basis. Percentage-wise, small cones had more small seed than large cones. In the 3-inch cones, 74 percent of the seed was in the small and medium size classes; in the 4-inch cones, 54 percent; in the 5-inch cones, 32 percent; and in the 6-inch cones only 29 percent of the seed were in these sizes. Small cones also had more sound seed per pound, with an average of 20,400, 17,800, 15,900, and 12,600 seed for the 3-, 4-, 5-, and 6-inch cones, respectively. This relationship is shown in Figure 4 by the regression line and reflects the above percent distributions of sound seed by seed sizes and cone lengths.

Seedling grades.—The percentage distribution of small, medium, and large seedling grades was 37.5, 43.1, and 19.4 percent, respectively, for all cone and seed sizes. When the seedlings were graded, a tally was made of the number in each stem-height and diameter class to determine the size class distribution. These data, which are based on 3,929 trees, are summarized in Table 2. The most common size with 29 percent of trees was 1 to 2 inches tall and 1/16 to 1/8 inch in diameter. About three-fourths of the seedlings tallied were between 1 and 3 inches tall and had a stem diameter of 1/16 to 1/4 inch.

Seedling grade at time of lifting was related to cone and seed size, and seedling weight was correlated with seed size. The larger seed tended to produce larger seedlings. Fifty-nine percent of the seedlings from small seed were graded as small seedlings, but only 27 percent from extra-large seed were so graded (Table 3). Similarly, on the basis of seedling weight, seedlings from extra-large seed weighed on an average 9.1 grams, but those from small seed averaged only 5.2 grams (Fig. 5).

The data in Table 4 show that for a given seed size the seed from small cones produced a higher proportion of large seedlings than did the seed from large cones. The reason seems to be that, for example, medium seed (2.83 to 3.36 mm.) represented the poorer seed from large cones but the better seed from small cones.

Discussion

First-year survival of planted seedlings in south Florida is one of the most crucial problems in reforesting cutover lands. Since there are a number of factors causing seedling mortality, each technique that improves survival is a step forward. In this study, grading seed, and to a lesser extent the cones, affected survival, but grading the seedlings from seeds of a given size had only a slight influence on survival.

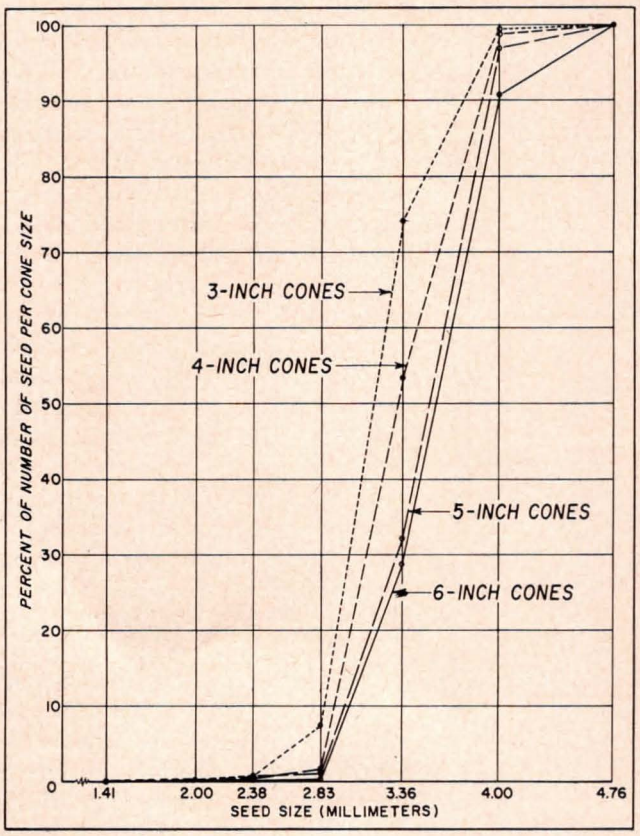

FIG. 3.—Cumulative percent distribution of seed by cone and seed sizes, South Florida slash pine, 1952 cone crop.

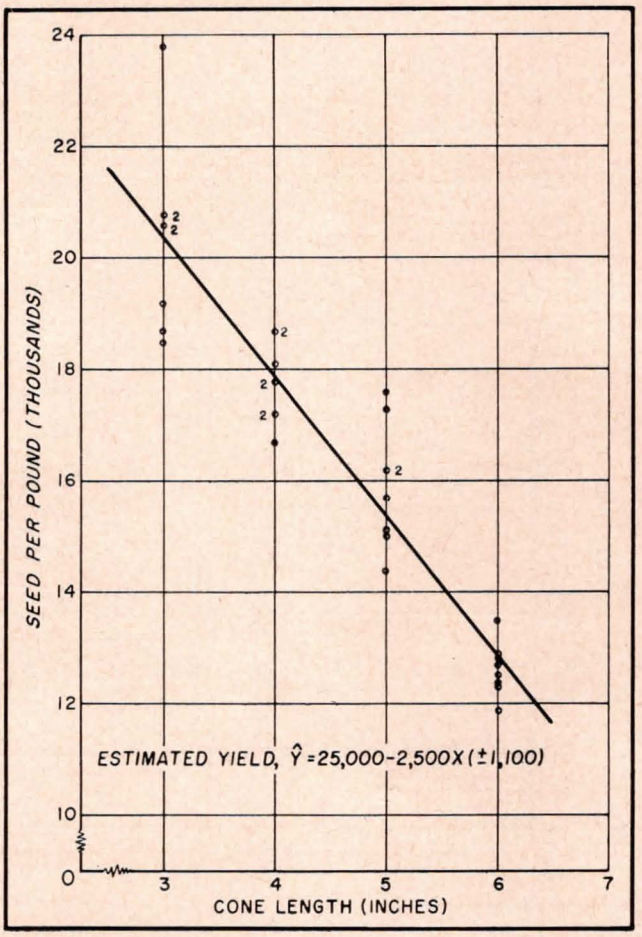

FIG. 4.—Regression estimate of number of sound seed per pound (Y) by cone length (X), South Florida slash pine, 1952 cone crop. Each point represents a 200-seed sample for a given cone-length class.

There are advantages to grading seed other than those of survival. Sowing rates in the nursery can be more closely controlled with graded seed. With graded seed, there will also be more uniformity in seedling size in the nursery bed, and the desired size can be attained by fertilization, which will result in fewer small seedlings. If these small seedlings are normally culled, lower proportion of culls would result in a lower cost of nursery stock. When planting seedlings from small seed, the expected mortality can be offset by planting closer than usual.

Grading by seedling sizes was effective in separating slow and fast growers during the first year. How long this effect will continue is unknown, but growth differences for other species have not been great after 10 or 15 years. Thus, for present grading recommendations, more weight has been given to survival results and considerations affecting planting costs than to early growth differences.

Intermediate-size cones may be

TABLE 2.—PERCENT DISTRIBUTION OF 1-0 SEEDLINGS BY STEM HEIGHT AND DIAMETER, SOUTH FLORIDA SLASH PINE

Height class (Inches)	Stem diameter class (inches)					
	1/16	1/16-⅛	⅛-¼	¼-⅜	⅜-½	Total
	Percent					
0-1	0.1	....	....	....	....	0.1
1-2	2.9	29.1	5.0	0.1	....	37.1
2-3	0.4	22.4	20.6	0.9	0.1	44.4
3-4	0.1	6 7	7.2	0.5	....	14.5
4-5	....	1.3	1.5	0.1	....	2.9
5-6	....	0.2	0.6	....	....	0.8
6-7	....	0.1	....	....	....	0.1
7-8	....	....	0.1	....	....	0.1
Total	3.5	59.8	35.0	1.6	0.1	100.0

TABLE 3.—PERCENT OF SEEDLINGS BY SEED SIZE AND SEEDLING GRADE, SOUTH FLORIDA SLASH PINE

Seed size	Seedling grade			
	Small	Medium	Large	Total
	Percent			
Extra-large	26.9	53.1	20.0	100.0
Large	31.3	46.4	22.3	100.0
Medium	43.2	39.1	17.7	100.0
Small	59.4	35.2	5.4	100.0
Average	37.5	43.1	19.4	100.0

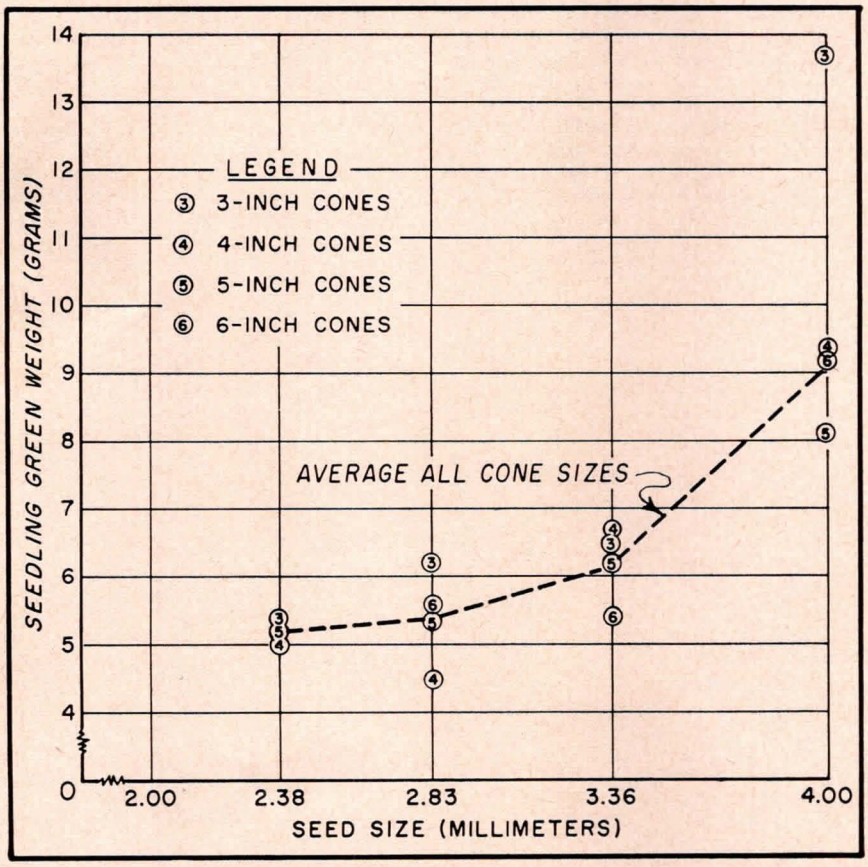

FIG. 5.—Relationship of seedling green weight to seed size and cone size, South Florida slash pine.

TABLE 4.—PROPORTION OF LARGE SEEDLINGS PRODUCED BY EQUAL NUMBERS OF SEED OF DIFFERENT SIZES OBTAINED FROM CONES OF DIFFERENT LENGTH

Cone length (Inches)	Seed size			
	Extra large	Large	Medium	Small
	Percent			
3	43.8	36.6	34.8	10.5
4	35.7	27.9	17.2	1.5
5	15.0	22.4	6.9	0.0
6	18.0	3.9	10.7	0.0
Average	20.0	22.3	17.7	5.4

the best size to collect on the basis of yield of sound seed per bushel of cones. In this study 4-inch cones yielded 22,300 sound seed per bushel of cones. Although the 6-inch cones yielded the highest *percentage* of large seed, 4- and 5-inch cones yielded the highest *number* of large seed per bushel of cones.

In 1952, the yield of sound seed per pound was highly correlated with cone size. If this relationship between cone size and seed size is consistent from year to year, it can be used to estimate the number of seed per pound for a given cone lot merely by sampling for cone size.

The cone-seed relationship may also help to explain the variation from year to year in number of sound seed per pound for other species. For example, variation in performance of seedlings from different seed sources might in certain instances be explained by cone and seed size relations.

Summary

Grading seeds for size was effective in separating seedlings of significantly different survival capacities when field planted in South Florida. Large seeds from small cones resulted in the best survival. Large and medium-size seedlings survived slightly better than small ones.

Grading by seedling sizes separated slow and fast growers during the first year after field planting. Large seedlings from small cones grew best during this period. Seed size did not significantly affect total height at one year after planting.

Preliminary recommendations for South Florida slash pine based on results of this study are:

1. Collect the ordinary-sized cones in preference to the larger ones. Grading of cones as a separate procedure is not recommended.

2. Grade seed by size to facilitate survival, nursery management, and seedling production.

3. Grade seedlings if seedling size will facilitate planting. It may help survival also.

4. In other research studies with this species, such as a seed-source study, cone and seed sizes should be evaluated to determine their effect on the results.

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